Section C

Geology and Soils

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GEOLOGY

Setting

The surficial geology of the Central Valley of California is a product of deposition of sediments. This deposition occurred first beneath an arm of the sea that filled the basin during the Paleozoic era (about 300 million years ago) and continued through the initial uplift of the Sierra during the Mesozoic (200 million years ago) and the Coast Ranges during the Miocene (20-25 million years ago). Not until the Pleistocene epoch 1 million years ago did the seas recede from the Central Valley, setting the stage for sedimentation by rivers and lakes. Materials carried from the Sierra and the Coast Ranges following the last major glaciation (10,000 years ago), forming great alluvial fans that filled the lakes that covered most of the valley floor. The courses of the rivers of the Central Valley were determined largely by the positions of the alluvial fans (City of Stockton 1980).

Seismicity

By California standards, Stockton is in a relatively low risk area for earthquakes. Most of the large fault systems lie to the west of the City. The San Andreas, Calaveras, Hayward, and Midland faults could generate earthquakes that would be noticeable but probably not damaging in Stockton. Stockton lies within Zone I, the low intensity earthquake severity zone (California Department of Mines and Geology 1973), but the moderate intensity zone, Zone II, lies immediately to the west of the City. Stockton is not in an Alquist-Priolo special study zone (Hart 1985).

The greatest earthquake hazard to development on the project site probably would result from movement along the Tracy-Stockton fault. This east-west trending fault is poorly defined at the earth's surface, and has been inactive near Stockton in historic time. However, three moderate quakes have been recorded near Linden since 1881. "There is . . . the possibility of an active fault capable of at least a 5.0 magnitude earthquake located in or near the central part of San Joaquin County" (ERME Support Document 1980).

Project Impacts and Mitigation Measures

Impact: Location of Project in an Area of Potential Seismic Hazard

Several characteristics of the project site give indication of a greater risk from earthquakes than prevails in other areas of Stockton. The site comprises recent sedimentary deposits, mainly poorly consolidated silts and clays overlying peat soils. The ground condition of this type of geologic unit has some very undesirable characteristics under seismic acceleration. The potential weakness of this substrate is compounded by the high water table common on the project site. Saturated alluvium is very unstable, and is the standard against which other ground condition units are ranked for instability (Evernden and Thompson 1985). The performance of saturated alluvium during an earthquake is, at best, unpredictable. Finally, flood protection on the project site is afforded by levees. Should seismically induced levee failure occur while rivers are at a high level, residents and structures would be subject to both earthquake and flood hazards; however, the risk of a damaging seismic event in Stockton is not high enough to warrant restricting new development. This impact is considered less than significant. To further reduce this impact, the following mitigation measures could be implemented.

Mitigation Measures

- Ground conditions on the project site increase the risk of damage from seismic acceleration. Materials used in construction of levees should be engineered to resist flow, slumping, or collapse during an earthquake. Sensitive structures (schools, medical and emergency facilities) should be subject to the kind of additional design and engineering control that takes poor ground conditions into account. The school site north of the lake is a particularly sensitive structure, because it is in an area underlain by 4-7 feet of peat soil.

- The City should prepare an emergency response plan to evacuate residents of the project site, in the event a strong earthquake occurs while the bordering rivers are at a high level, to reduce the public safety risk from flooding. Although the chances of having an earthquake during high river flow conditions are slight, prudence suggests that plans be made to deal with such a contingency. Should levees fail, the project site could quickly flood to depths of more than 7 feet during a 100-year flood event.

  The major components of most emergency response plans include:

  - establishing criteria for determining when an emergency exists;
  - identifying agencies and individuals responsible for emergency response and public evacuation;
  - designating evacuation routes;
  - selecting methods for notifying and evacuating residents;
  - preparing facilities to receive and support evacuees, including provision of shelter, food, and medical treatment; and
  - planning for the return of evacuees to their homes after an emergency is past.

Cumulative Impacts and Mitigation Measures

Impact: Earthquake Hazard

The cumulative effect of the proposed project and other Stockton developments on the seismic hazard is significant. Although the region is in a low to moderate seismic risk zone, emergency treatment facilities would be overloaded and emergency response plans would prove inadequate in a serious quake. Additional structures would require repair or demolition, and damaged levees would have to be reconstructed.

Mitigation Measures

- The severity of impact could be partially mitigated by the City's preparation of an emergency response plan for earthquakes, but the impact would remain significant.

SOILS--GEOTECHNICAL ASPECTS

Setting

The soils of the project site reflect the aquatic influences on the Central Valley and the Delta. Much of the soil parent material, and even the soil itself, was transported by rivers from the Sierra Nevada and the Coast Ranges. This material was sorted according to the energy available in the river, and was deposited either in the old Central Valley lake or as flood deposits in river floodplains. Formed in a fertile aquatic region, Delta soils often include organic material from decomposition of mats of plant debris. Peat soils, common in the Delta, are the products of plant decomposition. Although they are fertile and suited for agriculture if kept moist, peat soils are prone to deflation (oxidation, loss of structure, shrinkage, and compaction) if they are drained. Peaty soils are also unreliable as foundation material for structures.

A detailed geotechnical survey of the surface and subsurface soils on the project site was conducted by J. H. Kleinfelder & Associates during 1987. The Kleinfelder & Associates report presents findings from 39 test borings, plus 22 additional borings conducted earlier by Kleinfelder & Associates and Moore & Taber. The borings ranged from 10 to 20 feet in depth. The 1987 Kleinfelder & Associates report is the latest in a series of geotechnical studies dating back at least to 1974.

Surface soils on the site are generally dark brown to black organic silts and clays. The depth of this material ranges from 1 foot in the northern part of the site to a range of 4-11 feet in the west. Although these soils are often soft, they are stiff in some areas, or, as in the northeastern corner, cemented hardpan. Hardpans can be loosened by ripping, as part of agricultural operations.

Organic peats are found throughout the site, but the greatest depths of these organic soils are found in the southwestern corner (Figure C-1).

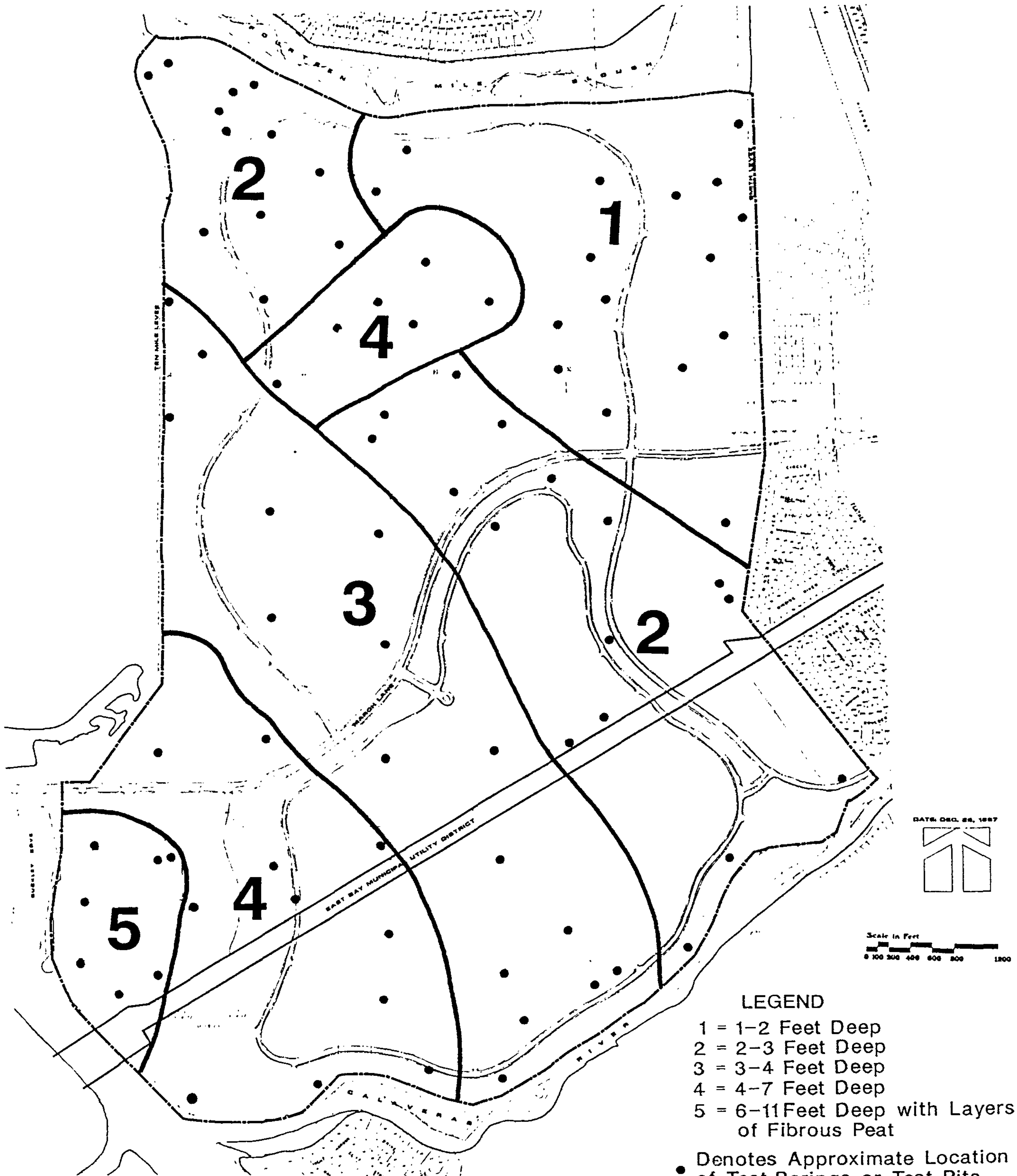

FIGURE C-1. APPROXIMATE DEPTH OF ORGANIC SOIL

Source: Kleinfelder & Associates, 1987

Bands of peat soils 1-3 feet thick are normally encountered at depths of 2-6 feet. However, significant spatial variation exists in the distribution of peat, with variations ranging from none to 11 feet of compressible organic silt and fibrous peat. Dry densities of these peats may be as low as 50 pounds per cubic foot or less.

Beneath the organic soils, bands of stiff to very stiff silty clay soil are found. At depths of 7-12 feet, these silty clays overlay lenses or strata of clayey silt, silty clay, and sands (Kleinfelder & Associates 1987). The complexity of the soil types and bedding patterns reflects the varied geologic history of the site.

Groundwater often was found near the surface. Although efforts are made on reclaimed land to maintain 4 feet of drain soil, groundwater on the project site was encountered in boring pits at depths of between 2.5 and 12 feet.

Project Impacts and Mitigation Measures

Impact: Location of Project in an Area of Soils with Construction Limitations

Significant impacts may be exerted on the proposed project by the geotechnical characteristics of the soils. The Kleinfelder (1987) report states that "the most significant factor influencing development of this area is the thickness and extent of the surface organic soils." The compressibility and instability of organic soils and peats pose severe problems for the construction of substantial structures, roads, and installation of utilities. The severity of problems varies roughly with the thickness of the organic soil layer. Figure C-1 shows the thickness of these organic soils. Even in relatively peat-free areas, Kleinfelder & Associates note that occasional pockets of fibrous peat or thick organic soils can be found. Hence, Figure C-1 can provide only general guidance to the thickness of organic soils found at any particular location.

Although light structures such as frame-detached houses could be built on shallow organic soils with relatively simple mitigation, differential loading could cause more difficult problems. For example, attaching a masonry fireplace to a frame house could cause differential loading and settlement of the structure, with resulting damage to the structure. This hazard becomes problematic on organic soils more than 3 feet deep (Areas 3, 4, and 5).

The project site development plan shows several problematic areas for construction. The southwestern corner of the site has the deepest deposits of peat (up to 11 feet). This area is slated for R-1 detached housing built upon fill placed to the elevation of existing levees. Significant problems with settlement and stability of the fill could be expected in this area, unless the peat is excavated prior to construction. A very large volume of peat spoils would be generated if excavation occurs. The deeply indented shoreline that is to be created would complicate the engineering of the fill/levee structures required to safely support housing, roads, and services, provide flood protection, and tie into the existing levee system.

Most of the golf course and its integral housing lies in peat areas 3 and 4 (3-7 feet of peat). Carefully engineered foundations are necessary to ensure the structural soundness of homes built in this area. In construction and contouring the golf course, the peat should be kept moist to prevent desiccation and deflation. The cell of peat Area 4 in the north-central portion of the site also should be subject to careful engineering to ensure the structural soundness of its R-1 detached housing and school.

Construction of roads over organic soils with high groundwater tables in the project to the east of the project site required that unstable organic material be removed and replaced with engineered fill. Installation of underground utilities, water lines, and storm drains would be more difficult on the project site than at the adjacent development due to the high groundwater table and weaker subgrade soils (Kleinfelder & Associates 1987).

The SCS has identified limitations of some project site soils for development. The Egbert mucky clays and Jacktone clays in the northern half of the site (Figure C-2) are limited for homesites because of characteristically slow permeability, a perched water table, high shrink-swell capacity of the clays, and low strength. On the Scribner clay loams in the southern portion of the site, the subsidence problem is added to this list. The peaty character of the Peltier mucky clay loams in the southwestern corner of the site causes problems of differential subsidence even for farming operations. In all areas of the Brookside property, community sewage systems are needed to prevent contamination of groundwater from ground disposal systems.

In summary, the geotechnical impacts above are considered significant and can be reduced to a less-than-significant level by implementing the engineering measures recommended by Kleinfelder and Associates.

Mitigation Measures

o Areas 1, 2, and 3 on Figure C-1 are suitable for spread and continuous foundations. Kleinfelder & Associates recommend the use of one standard conservative foundation design criterion for dealing with soil conditions, rather than many different criteria. The firm's recommendations for Areas 1, 2, and 3 are shown in Table C-1.

These criteria can be applied to commercial, recreational, and school buildings, but in some cases it may be more prudent and economical to use deeper foundations. Also, the foundation could be extended through the organic soils to more stable subsoils, drilled piers, or post-tensioned slabs and foundations. The organic material could be removed and replaced with nonexpansive, stable, imported material. Raised foundations offer an advantage over using slab-on-grade foundations that allow periodic leveling of structures with screw jacks.

o Differential loading in Areas 1, 2, and 3 could be reduced by designing foundations to distribute the weight of fireplaces to adjacent footings or slabs.

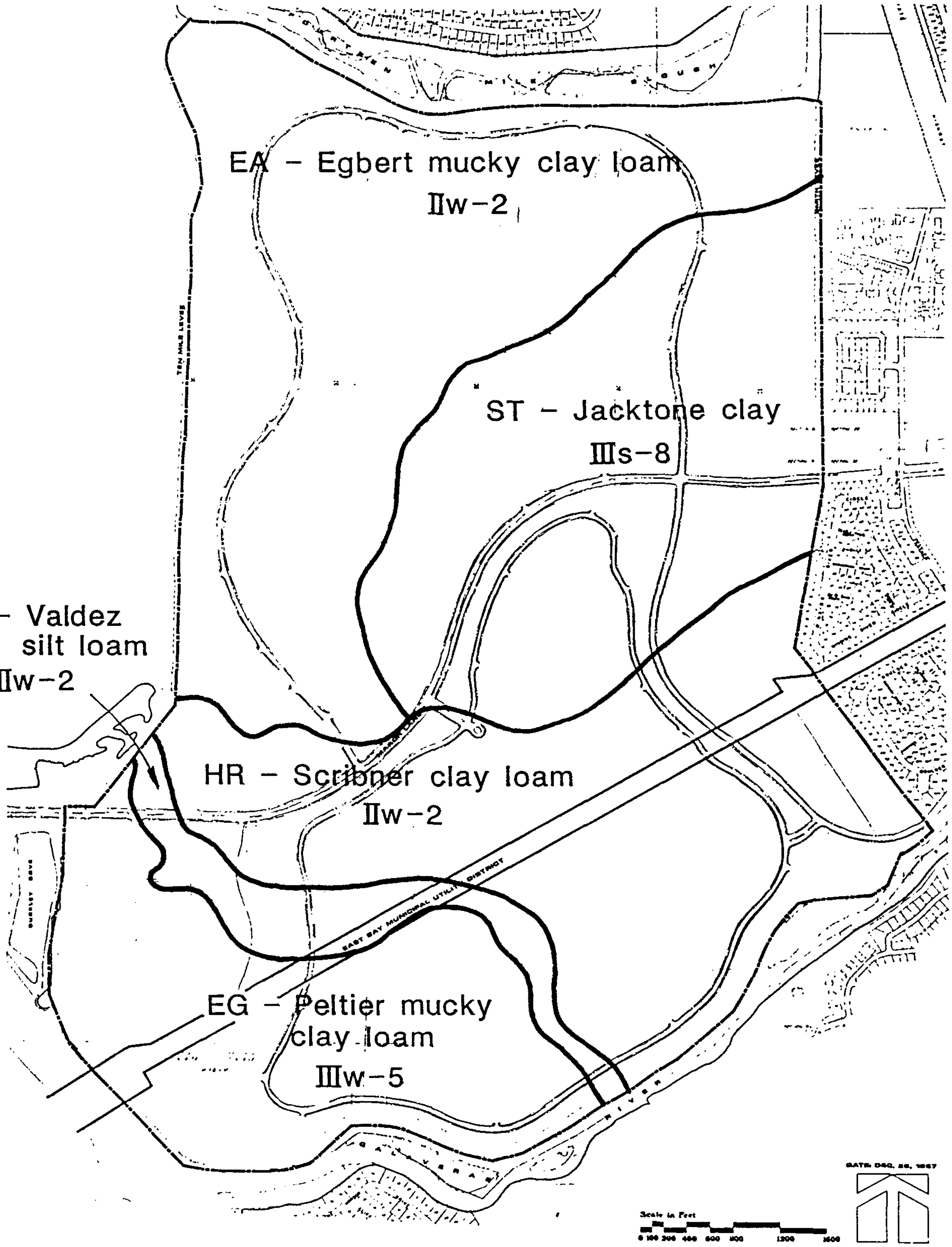

FIGURE C-2. SOIL MAPPING UNITS AND LAND CAPABILITY CLASSIFICATIONS

Source: U.S. Soil Conservation Service Preliminary Investigations

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Table C-1. Foundation Design Criteria

Area	Allowable Soil Bearing (psf)	Recommended Reinforcement Criteria	Minimum Depth (inches)	Range of Total Settlement (inches)
1	1,000	Unified Building Code	12	0 to 0.25
2	750	Span-unsupported length of 10 feet	18	0.25 to 0.50
3	500	Span-unsupported length of 15 feet	18	0.50 to 0.75

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- In Areas 4 and 5, where organic soils exceed 4 feet in depth, more extensive foundations would be needed. These include "pier and grade beam, overexcavation and replacement, and grid, mat or post-tensioned foundations. . . . For residential homes . . . pier and grade-beam foundations will generally be the most cost effective" (Kleinfelder & Associates 1987).

- In the southwestern portion of the site, where levee heights must be matched, preloading and building upon engineered fills also could be considered. To permit settling to occur, several months to a year must be allowed before construction can begin on these fills.

- Additional mitigation of problems encountered when building on organic soils could be obtained by following recommendations in the Kleinfelder & Associates (1987) report. These actions include:

  -compacting soil prior to construction;
  -underlaying slabs with layers of gravel, coarse sand, moisture-proof membranes, and moist sand;
  -moisture conditioning of soil under and around foundations;
  -striping and removing of all vegetative material during site preparation;
  -careful drainage of construction sites; and
  -overseeing of construction activities by a geotechnical engineer.

- Road construction in Areas 1, 2, 3, and 4 would require mitigation by lime treatment and/or use of aggregate subbase and base. Lime treatment has proven successful for certain road building conditions on peat soils in the Stockton area. Mixing lime with clay soils can reduce the tendency of the clays to become plastic and lose bearing strength when wet. Such mixing is especially useful in the engineering of road subgrades. Once liming has been completed, it is not affected by high water table events, and is most effective in increasing bearing values of clays when wet. In the southwestern corner of the site (Area 5), the great depth of peat requires use of engineered fill pads, perhaps in combination with geotextiles.

- In preparing to install underground utilities, the following mitigation measures should be followed:

  - Dewatering of excavations shallower than 4 feet should be performed by sumps, but wells would be necessary for deeper cuts.
  - Cuts in soils with over 4 feet of organic material should have temporary slope angles of 1:1, and excavated soils should not be stored at the top of the cut.
  - Flexible utility connections should be used where estimated total building settlement exceeds 1 inch.
  - Peat should not be used as backfill material, but should be replaced with more stable material such as sand or silty sand.

Cumulative Impacts and Mitigation Measures

Impacts: Construction on Peat and Shrink-Swell Soils

The impact of building housing on soils of variable engineering qualities is strictly site-specific. Therefore, the cumulative impacts of the proposed project and other developments do not affect the significance of the impact.

Mitigation Measures

- If foundation designs, construction techniques, and land use controls are implemented in response to soil limitations, the cumulative impacts of engineering characteristics of soils in the Stockton region could be reduced to less than significant.

SOILS--AGRICULTURAL PROPERTIES

Setting

The Central Valley contains some of the most fertile and productive agricultural soils in the world. The flat topography, abundance of irrigation water, moderate climate, generally excellent soil, physical and chemical characteristics, and highly developed farm support infrastructure have made possible a state agricultural economy that is richer than that of most nations. California's agricultural produce is sold around the world, and the value of the state's soils should be viewed from a global, not just a local, perspective. Agricultural soil is often classified as a "critical zone" resource. This means that if it is well managed, it is renewable and can be used for many years. If poorly managed, or if converted to other uses, soil becomes a nonrenewable resource.

As discussed in the previous section, the peat soils of the Brookside property are overlain by silt or clay soils. The high water table also keeps the peat soils hydrated throughout much of the year. This is a fortuitous circumstance, because the surface silt/clay soils prevent or retard the oxidation and deterioration of organic soils that is common if the peat is exposed to air at the surface. The presence of the peat soils on the project site constitute a reservoir of organic matter beneath the site that is within the rooting zone of most crop plants.

The SCS has identified five soil mapping units on the project site. Their distribution is shown in Figure C-2. Land capability classifications have been assigned to each of these mapping units. This information is preliminary and subject to review and revision by the SCS.

Capability

All of the project site falls into capability classes II or III, indicating "some" to "moderate" limitations to crop production. Two capability subclasses are present, which explains the nature of the limitations to production. Subclass "s" is a limitation in the rooting zone, in this case shallow rooting depth. It is further clarified by subclass number "8," denoting that the limitation is "caused by shallow depth of soils to hard bedrock or an indurated layer" (U. S. Soil Conservation Service 1971). Subclass "w" signifies that excess water from poor drainage or a high water table is a problem, as explained by numbers "2" and "5". Limitation "2" indicates poor drainage or flooding, and "5" represents fine-textured surface soil that impedes infiltration. Most of these limitations can be reduced by good soil management, installation of drainage facilities, and careful application of irrigation water. Under current management, the soils of the Brookside property fit the classification of "prime" farm land as defined by the SCS's Important Farmland Inventory system (Allen 1982).

Mapping Units

Soils are not uniform, even within mapping units. The spatial variability of the mapping units identified by the SCS ranges from 15 to 20 percent. That is, 80-85 percent of the area of a given mapping unit fits the description of the mapping unit title, such as Valdez silt loam. But 15-20 percent of the mapped area may contain soil with characteristics of other mapping units. These other units are noted in the SCS description of the mapping unit, but their distribution is not shown on soils maps.

The northern and western margins of the project site fall into the mapping unit category of Egbert mucky clay loams, EA. The clay loams extend to a depth of approximately 60 inches. Runoff is slow and the soil erosion hazard is slight. The wind erosion hazard is slight to moderate when the soil is bare. When irrigated, the main limitation to crop growth is a perched water table at a depth of 4-5 feet. The EA zone is in land capability class IIw-2 (irrigated).

Approximately 20 percent of the project site is classified as being in the Jacktone clay mapping unit, ST. A dark gray clay surface layer extends to a depth of 28 inches, overlaying clay loams to a depth of 34 inches. Then a strongly cemented to indurated hardpan about 3 inches thick is encountered. This and lower hardpan layers impede soil drainage. Permeability of the Jacktone unit is slow, and effective rooting depth is 2,040 inches. The water table is at a depth of 5 feet or more, but water may be perched on the hardpan after heavy rains or irrigation. The main limitation to crop production is the slow permeability and the hardpan. Ripping the hardpan to a depth of 60 inches, coupled with care in applying irrigation water, can help to overcome the limitations of this unit. The ST unit is in land capability class IIIs-8 (irrigated).

The Scribner clay loam (HR) mapping unit covers about one-quarter of the project site. It is a deep, poorly drained soil formed in alluvium weathered from mixed rock sources. A surface layer of dark gray, mottled clay loam extends to a depth of 24 inches. The next layers are mottled fine sandy loam (8 inches), loam (10 inches), and silty clay and fine sandy loam (22 inches). Permeability is moderately slow, and rooting depth is limited by a perched water table at depths of 3-5 feet. Runoff is very slow and the risk of water erosion is slight. The main limitation to crop production is the perched water table. This can be overcome by drainage and careful irrigation. Map unit HR is in land capability class IIw-2 (irrigated).

The Peltier mucky clay loams (map unit EG) in the southwestern corner of the project site are common to river deltas and floodplains. The soil is derived from mineral sediments from mixed rock sources and hydrophytic plant remains from reeds and tules. The surface gray mucky clay loam is about 22 inches thick. It overlays 23 inches of mottled clay loam, followed by 15 inches of olive gray mottled clay. Permeability is slow, runoff is very slow, and the water erosion hazard is slight. The effective rooting depth is limited by a perched water table at a depth of 3-4 feet. Slow permeability, high water table, and differential subsidence are the primary limitations to crop production. Frequent planing of fields may be necessary to maintain efficient irrigation. Areas adjacent to levees are recommended for winter flooding to reduce hydraulic pressure on adjacent levees. The flooded areas can be used for winter waterfowl habitat. The EG mapping unit is in capability class IIIw-5 (irrigated).

A narrow band of Valdez silt loam (mapping unit VZ) snakes through the southern quadrant of the project site. Its character is very similar to that of the adjacent Peltier mucky clay loam. Mapping unit VZ has a land capability class of IIIw-2 (irrigated).

Project Impacts and Mitigation Measures

Impact: Conversion of Agricultural Soils

The conversion of the project site from agriculture to urban development would have a significant, irreversible impact upon agricultural soils. These 1,200 acres of prime soils would no longer be used as a renewable agricultural resource, but as substrate for building foundations, material for levee reconstruction, and for a golf course. Although the use of the golf course to produce crops in response to some future need is conceivable, it is extremely unlikely. The removal from production of these prime soils would constitute a recurrence of the common practice of using local criteria of best use to allocate resources that have statewide, national, or even global value. Thus, this impact is considered to be significant.

Mitigation Measures

- None available.

Cumulative Impacts and Mitigation Measures

Impacts: Conversion of Agricultural Soils

The cumulative effect of the Brookside project and other Stockton projects would have significant impacts on the agricultural soils of the region. The Brookside project adds 1,200 acres to the 2,288 acres in other developments approved in the 1987 ballot, much of which is prime agricultural land. This compounds the regional and statewide problem of conversion of agricultural land and increases competition by urban uses for land and irrigation water.

Mitigation Measures

- o None available.

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